EXHIBIT D

IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF OKLAHOMA

STATE OF OKLAHOMA, ex rel. W.A. DREW EDMONDSON, in his capacity as ATTORNEY GENERAL OF THE STATE OF OKLAHOMA and OKLAHOMA SECRETARY OF THE ENVIRONMENT C. MILES TOLBERT, in his capacity as the TRUSTEE FOR NATURAL RESOURCES FOR THE STATE OF OKLAHOMA

Plaintiffs,

vs.

1. TYSON FOODS, INC.,
2. TYSON POULTRY, INC.,
3. TYSON CHICKEN, INC.,
4. COBB-VANTRESS, INC.,
5. AVIAGEN, INC.,
6. CAL-MAINE FOODS, INC.,
7. CAL-MAINE FARMS, INC.,
8. CARGILL, INC.,
9. CARGILL TURKEY PRODUCTION, LLC.,
10. GEORGE'S, INC.,
11. GEORGE'S FARMS, INC.,
12. PETERSON FARMS, INC.,
13. SIMMONS FOODS, INC., and
14. WILLOW BROOK FOODS, INC.,

Defendants.

Case No. 4:05-cv-00329-GKF-SAJ

EXPERT REPORT OF DR. CHRISTOPHER M. TEAF

Qualifications & Experience

1. My name is Dr. Christopher M. Teaf. I am over 18 years of age and am competent to testify. All opinions presented in this statement reflect personal knowledge based on information and data that I have reviewed in this case. All

12. In 2003, the Oklahoma Secretary of the Environment issued a formal report stating that the general health and the water quality of the Illinois River were endangered by pollution from stormwater that runs off from poultry operations or from fields on which waste has been spread (OSE, 2003). Additionally, Engel (2008) developed an approximate poultry waste generation (tonnage) amount for each of the Defendants on a monthly basis, an annual basis, as well as the entire time frame of 1998-2006. His conclusions were that the vast majority of poultry waste generated inside the IRW is disposed inside the IRW, and that a significant amount of poultry waste generated outside of the IRW is disposed inside the IRW as well. Fisher (2008) has reviewed the geology and hydrology of the IRW and has concluded that the IRW is an area of high permeability and that groundwater is particularly susceptible to impact by surface contamination, including land-applied poultry waste. He also has provided estimates of the timing of poultry waste application during the year. Harwood (2008) has addressed a number of critical issues related to bacterial occurrence, origin and significance, concluding that poultry waste poses significant health issues for river users in addition to posing serious environmental problems for the entire IRW. Through various matrix samples, Harwood identified a unique bacterial biomarker which indicates that IRW contamination can be linked specifically to poultry operations and poultry waste land disposal practices.

13. Olsen (2008) has addressed a variety of chemistry and data collection issues to characterize impacts to the IRW, and has demonstrated by evaluating metals, nutrients, other analytes, physical measurements, and indicator organisms, a unique poultry-related chemical "signature". Through his analyses, he concluded that the "signature" has been and is present in environmental samples collected throughout the IRW. Olsen makes the additional distinction that the unique poultry "signature" in surface water is <u>not</u> found in the absence of poultry operations. In addition, statistical measures of common presence for a variety of analytes and microbiota (e.g., Principal Component Analysis or PCA) have been addressed by Olsen (2008). Those measures support a conclusion that the bacterial impacts are related to, and occur coincident with, land application of poultry waste, including manure and litter (CDM, 2008).

99% of that usage type occurs in the months of May through September (Caneday, 2008; Figure B3). Floating includes ancillary direct contact activities in the water such as swimming and wading as well, and reasonably can be considered to include an ingestion component of exposure, as well as dermal. Thus, a very large proportion of total annual land spreading of poultry waste is conducted during the months which just precede or overlap with the times of maximum direct contact recreational use of the Illinois River and its tributaries. Coincidentally, the rainy season in Oklahoma tends to be between February and June (NOAA, 2000), which coincides with and immediately follows the highest rates of waste application (Adamski, 1987; Adamski & Steele, 1988; Fisher, 2008). The rainy season also immediately precedes the highest rates of floating activity (Figure B4). On average, approximately 45% of annual rainfall in Northeast Oklahoma occurs between the months of February and June (NOAA, 2000). Rainfall, specifically when it occurs shortly after land spreading, results in microbial pathogen distribution as a result of runoff from spread poultry waste or by leaching through the soil profile (Giddens and Barnett, 1980; Gagliardi and Karns, 2000; Fisher, 2008; Olsen, 2008), even if buffer zones are used correctly, which they frequently are not.

26. Recently, over six consecutive years (2000-2005), there has been widespread measurement of the presence of indicator organisms in surface waters of the IRW, which indicate that those waters broadly and regularly exceed the Oklahoma Water Quality Standards and/or health-based screening levels (OWRB, 2007; CDM, 2008). Single point criteria for surface water along the impaired water body segments from recreational seasons 2005-2007 were exceeded in a large number of samples. Most of these samples are at least twice the standard and the values may exhibit exceedances up to a maximum of 125 times the standard (Table B2). Another example of regular and widespread exceedances of particular interest exist in specifically identified public access (PA) locations (Figure B5), most of which are within impaired water body segments, where a remarkable 13 of 15 locations (nearly 90%) had results where one or more indicators were in excess of the Oklahoma standards for fecal bacteria as shown by indicator organisms (CDM, 2008). In addition to single point criteria, a number of multi-sample geometric means within impaired water body segments, according to the

procedures of the Oklahoma Water Resources Board, also showed exceedances. The State of Oklahoma mandates that a geometric mean calculation for Primary Body Contact Recreation have no less than five samples for any 30-day time frame of interest (OAC, 2007). Results for the recreational seasons of 2005-2007 show exceedances in all water bodies where sufficient samples were taken to perform the calculation, with those exceedances being in the range of 2 to 30 times the standard (Table B2). While Peacheater Creek, Tyner Creek, Tahlequah Creek, and a portion of the Illinois River did not have adequate sampling frequency within the specified time frame to fairly calculate the geometric mean, the percentage of single point criterion exceeding the standard was in most cases nearly 20% of the samples, at levels that were 2 to 65 times greater than the health-based screening level (CDM, 2008; Table B2). These results, in my opinion, demonstrate a chronic and persistent problem of bacterial contamination which represents an imminent and substantial endangerment.

27. In addition to Primary Body Contact Recreation uses associated with surface water exposures, significant exposures to contaminated groundwater can occur through drinking water supplies as well. In Oklahoma, groundwater is protected such that bacterial levels in groundwater must be "nondetect", which is reasonable based on the absence of normal bacterial fauna in groundwater at deeper depths (NRC, 2004; EPA, 2006A; USGS, 2007b). Once groundwater pollution has been determined to have occurred via human activities, the water supply is to be restored to a quality sufficient to support its designated beneficial use, in this case potable water supplies (OAC, 2007). Over 1,700 groundwater wells have been identified in the Oklahoma portion of the IRW, of which 98% are used for domestic purposes (OWRB, 2008; Fisher, 2008; Figure B6). Figure B7 illustrates the CDM groundwater well sampling sites within the IRW while Figure B8 shows the locations of Geoprobe samples taken within the IRW. Bacterial contamination of groundwater, including impacts by *E. coli*, fecal coliforms and enterococci, has been demonstrated in many shallow wells and in other wells at depths to approximately 150 feet, as well as in a majority of shallow groundwater Geoprobe samples (CDM, 2008). Olsen (2008) identified the poultry "signature" in the majority of these samples. While these Geoprobe samples are not necessarily

completed to depths from which groundwater is taken for domestic purposes, they clearly demonstrate the potential pathway between microorganisms at the surface and those which can contaminate groundwater. These elements further demonstrate the vulnerability of shallow groundwater (NRC, 2004; Fisher, 2008), and illustrate the health concerns that are associated with land spreading of poultry waste in areas where groundwater is used for potable and other domestic purposes.

28. Bacterial levels of human health significance also have been found in a number of springs within the IRW. At their point of release from the ground, where they "daylight", springs represent a transition from groundwater to surface water. Thus, they can be indicators of impacts to groundwater and/or surface water (Fisher, 2008). Springs sampled in the Oklahoma portion of the IRW are shown in Figure B9. Approximately 21% of the spring samples exceeded the surface water bacterial standards. Most of those samples were located in close proximity to the Illinois River and its tributaries. Olsen (2008) concluded that nearly 40% of spring samples were impacted by poultry waste.

29. Bacteria have been detected in surface water, groundwater and springs in the IRW at levels that are indicative of significant concern from a human health perspective (CDM, 2008). Edge-of-Field samples for fields that have received recent spreading of poultry waste have shown bacterial colony counts in water which are similar to those reported for water samples into which, raw, untreated sewage (i.e., 10^5 or 100,000 MPN or greater) has been spilled from U.S. sewage treatment plants (Metcalf & Eddy, 1991; Brosnan et al., 1996; CDM, 2008; Harwood et al., 2005). Of the 22 Edge-of-Field sample locations which exhibited bacteria and indicator organism results in excess of 100,000 MPN per 100 milliliters, seven of the locations exhibited results for enterococci, fecal coliforms and/or total coliforms greater than or equal to 1,200,000 MPN per 100 milliliters, with three sites having a total of 5 reports of greater than or equal to 1,600,000 MPN per 100 milliliters (Table B6). Through Principal Component Analysis (PCA), it has been determined that 100% of the Edge-of-Field samples showed poultry related impacts. Furthermore, of the 50 highest "PC1" (poultry) scores of all sampled media, 44 were Edge-of-Field samples, with the highest score resulting in a sample

taken from field runoff immediately after poultry waste application (Olsen, 2008). In addition, the maximum levels for *E. coli*, enterococci and fecal coliform found in poultry litter/waste samples collected by CDM in 2006 were 120,000 MPN per gram of litter (CDM, 2008). Other impacted media include sediments and soils as demonstrated by Fisher (2008) and Olsen (2008).

30. In addition to the numerical comparisons between health-based criteria and detected levels of bacteria and indicator organisms as a measure of potential health hazard, it is useful to consider the relative importance of microbial sources in the IRW as well. Processes to accomplish this have been developed by USEPA and a number of individual states, including Oklahoma, under the Total Maximum Daily Load (TMDL) program (USEPA, 1997; USEPA, 2001b; ODEQ, undated).

31. An analysis of potential sources for fecal coliforms was conducted in a fashion consistent with that employed by USEPA and ODEQ for the six counties which share some portion of the Illinois River Watershed (Adair, Cherokee, Delaware and Sequoyah in OK; Benton, Washington in AR). That analysis considered fecal coliform contributions by a variety of categories for which data were available, including: domestic pets, deer/wildlife, failing septic systems, permitted point sources (i.e., NPDES outfalls), and livestock. The livestock category was further subdivided into groups by poultry, cattle/calves, horses/ponies, sheep/lambs, and swine. Table B4 summarizes the contributions for each source category, and also provides a summary of the relative contribution from the five livestock categories. The numerical values for each category are expressed in units of Colony Forming Units per day (CFU/day). For example, the total fecal coliform load from poultry and from cattle/calves is approximately 5×10^{15} CFU/day, or 5,000 trillion CFU/day each. Table B5 provides the underlying summary calculations and input parameters for the values presented on Table B4.

32. Several important conclusions can be drawn from this source contribution analysis, including the following:

52. CDM collected water samples on three separate occasions in 2006 from 5 locations within three different IRW public water systems and analyzed them for TTHM and HAA5s. These locations are depicted in Figure T3. Of the total 45 samples collected, there were 6 exceedances and 5 near exceedances of the TTHM MCL (24%) and 3 exceedances and 1 near exceedance of the HAA5s MCL (9%). All of the samples exceeded the risk-based values for bromodichloromethane and dibromochloromethane and dichloroacetic acid, while two of the samples exceeded the individual chloroform MCLG of 0.070 mg/L. Six of the samples were greater than the MCLG of 0.02 mg/L for trichloroacetic acid. These results are illustrated in Table T2. In addition, raw water samples collected during the recreational season of 2005, 2006 and 2007 were evaluated for THM-forming potential (THMFP; CDM, 2008) and 71% of the results (57/80) showed values in excess of the TTHM MCL at twelve different locations along the Illinois River and in Lake Tenkiller. Table T3 shows the average THMFP from five PWAs. These report several of the larger systems which withdraw, treat and distribute water from the IRW.

53. Beyond the increased human health risks, elevated levels of THMs and HAA5s in drinking water often result in esthetic concerns (e.g., disagreeable taste and odors) in water supplies at concentrations which are at or near the drinking water standards (USEPA, 2006c). Thus, the water supply may be in compliance with regulatory numerical standards, but may not meet the Oklahoma narrative standards for water supplies. This general narrative criteria, found in OAC 785:45-5-9, states that "taste and odor producing substances from other than natural origin shall not interfere with the production of a potable water supply by modern treatment methods..." and "shall be maintained at all times to all surface waters of the state" (OAC, 2007). This criterion has not been met on many occasions in the IRW. In addition, the general criteria for public and private water supplies found in OAC 785:45-5-10 (5) (A) states that "The quality of the surface waters of the state which are designated as public or private water supplies shall be protected, maintained, and improved when feasible, so that the waters can be used as sources of public and private raw water supplies". In this case the water bodies in the IRW are not being adequately protected. Also found in that criterion is OAC

61. The measurement of "chlorophyll a" (Chl) concentration is used as another indicator of the abundance of algal growth (including cyanobacteria) in water bodies. Chl concentrations are used to define trophic state (or nutrient content) of water bodies and can be related to taste and odor issues. Cooke and Welch (2008) noted that the probability of cyanobacteria "blooms" rise sharply when mean summer Chl concentration is above 10 µg/L. Two sources of lake water odors that reasonably may be related to trophic state (e.g., eutrophication) have been described as high concentrations of specific algal species and bottom water odors that result from substances released from the sediment under anoxic (i.e., low oxygen) conditions (Arruda and Fromm, 1989). Existing regulations [OAC 785:45-5-10 (7)] describe the numerical criterion for Chl as "The long term average concentration of chlorophyll-a at a depth of 0.5 meters below the surface shall not exceed 0.010 milligrams per liter" in Lake Tenkiller (OAC, 2007). In this instance, "long-term average" is defined as the "arithmetic mean of at least 10 samples taken across at least 12 months" (OAC, 2007). Results from CDM sampling, as shown in Table C1, at four locations on Lake Tenkiller show that this long-term average criterion was exceeded during 2005-2006 at two of the four locations sampled with the long-term averages of 15.9 and 27.1 µg/L at LK-03 and LK-04, respectively (CDM, 2008). The other two locations, LK-01 and LK-02, had long-term average values of 6.4 and 8.7 µg/L, respectively. Although there were not enough samples to calculate long-term averages from the acquired Oklahoma Water Resources Board (OWRB) Chl data, calculated averages from 1999 through 2006 (between 10 and 15 samples at each site) at 7 locations on Lake Tenkiller show levels above 10 µg/L Chl at four of the locations (OWRB, 2006). These seven locations are illustrated in Figure C1.

62. WHO (1999) guidelines are widely used in the public health community to evaluate potential risks that may be posed by cyanobaceria in water supplies. Those guidelines state that at a density less than 20,000 cells/mL of cyanobacteria there exists relatively low risk of adverse human health effects, while at or above 100,000 cells/mL there is moderate risk and, when visible scum of cyanobacteria is present, there is high risk of adverse health effects. Pilotto (1997) has suggested that these guidelines, while

they are commonly employed, may not in and of themselves be adequate to protect human health.

63. Results from sampling by CDM (2006, 2007) and OWRB and U.S. Army Corps of Engineers (ACoE; 2004, 2005) from several different locations (Figure C1 and C2) on Lake Tenkiller during August 2004 through August 2007 showed that approximately 58% of all samples (233/404) exhibited cyanobacterial densities of greater than 20,000 cells/mL. In addition, as listed in Table C2, approximately 24% (55/233) of those samples that were greater than 20,000 cells/ml exceeded 100,000 cells/mL (moderate risk), and one June 2006 sample exceeded 1,000,000 cells/mL.

64. Cell sizes of the cyanobacteria can vary considerably within and between species, therefore cell numbers alone may not be the only or the ideal measure of population size or potential toxicity risk (WHO, 1999). It is possible for biological volume of cells ("biovolume") to be estimated from cell counts and average cell volumes, and the resultant converted data reported as micrometers cubed per milliliter of water (μm^3/mL). However, no federal or state standards currently are available for comparison with measured biovolume values. When compared to measuring cyanobacterial genotypes, Janse et al. (2005) found that the monitoring of algal biomass/biovolume can be an adequate predictor of toxin production. The ACoE collected samples during the period from 2001 through 2004 from four different locations along Lake Tenkiller (Figure C2), and reported cyanobacteria in units of biovolume. These results are shown in Table C3 and show biovolume levels ranging from 1,800 to 60,802,075,714 μm^3/mL (over 60 billion μm^3/mL). Of the 128 total samples, 64% were greater than 1,000,000 μm^3/mL, 28% were greater than 100,000,000 μm^3/mL, and 20% were greater than 1,000,000,000 μm^3/mL. Cyanobacteria biovolume ranges for all of the CDM and OWRB samples that were greater than 20,000 cells/mL ranged from 22,000 μm^3/mL to 13,000,000 μm^3/mL. Thus, despite the absence at present of a rigorous biovolume standard, these results clearly represent potentially harmful amounts of cyanobacterial algal growth along Lake Tenkiller over four consecutive seasons.

Table B4

Estimated Fecal Coliform Sources in IRW (Oklahoma & Arkansas)

Estimated Total Fecal Coliform from All Sources by County (CFU/day)							
Counties in Watershed	Domestic Pets	Deer/ Wildlife	Failing Septic Tanks	Point Sources	Livestock	Total	Percentage
Adair	1.30E+13	2.75E+12	2.15E+12	1.35E+10	2.10E+15	2.12E+15	18.1%
Benton	6.36E+12	1.24E+12	4.76E+13	1.70E+11	3.64E+15	3.70E+15	31.5%
Cherokee	1.98E+13	3.88E+12	2.80E+12	3.99E+10	5.18E+14	5.45E+14	4.6%
Delaware	3.48E+12	5.86E+11	7.05E+11	0.00E+00	4.21E+14	4.26E+14	3.6%
Sequoyah	3.89E+12	6.11E+11	5.05E+11	0.00E+00	1.10E+14	1.15E+14	1.0%
Washington	7.57E+12	2.26E+12	4.94E+13	6.15E+11	4.77E+15	4.83E+15	41.2%
Total	5.41E+13	1.13E+13	1.03E+14	8.38E+11	1.16E+16	1.17E+16	100.0%
Percentage	0.5%	0.1%	0.9%	0.01%	98.6%		100.0%

Estimated Total Fecal Coliform per Livestock Type by County (CFU/day)							
Counties in Watershed	Poultry (ALL)	Cattle & Calves	Horses & Ponies	Sheep & Lamb	Swine	Total	Percentage
Adair	4.15E+14	1.42E+15	6.97E+11	5.22E+12	2.55E+14	2.10E+15	18.1%
Benton	1.81E+15	1.27E+15	6.75E+11	3.95E+12	5.52E+14	3.64E+15	31.5%
Cherokee	4.68E+13	4.67E+14	3.88E+11	7.80E+11	2.55E+12	5.18E+14	4.5%
Delaware	1.12E+14	1.88E+14	1.11E+11	4.20E+11	1.20E+14	4.21E+14	3.6%
Sequoyah	5.43E+12	1.03E+14	1.26E+11	7.20E+10	8.77E+11	1.10E+14	0.9%
Washington	2.36E+15	1.68E+15	1.27E+12	5.02E+12	7.26E+14	4.77E+15	41.3%
Total	4.75E+15	5.13E+15	3.27E+12	1.55E+13	1.66E+15	1.16E+16	100.0%
Percentage	41.1%	44.4%	0.03%	0.1%	14.3%		100.0%